The CAA-MIT Microwave Instrument Landing System

Discussion of paper 40-44 by E. L. Bowles, W. L. Barrow, W. M. Hall, F. D. Lewis, and D. E. Kerr, presented at the AIEE winter convention, New York, N. Y., January 22–26, 1940, and published in AIEE TRANSACTIONS, 1940, pages 859–65.

C. Francis Harding: See discussion, this page.

The Development of the Civil Aeronautics Authority Instrument Landing System at Indianapolis

Discussion of paper 40-43 by W. E. Jackson, A. Alford, P. F. Byrne, and H. B. Fischer, presented at the AIEE winter convention, New York, N. Y., January 22–26, 1940, and published in AIEE TRANSACTIONS, 1940, pages 849–58.

Harry Diamond (National Bureau of Standards, Washington, D. C.): It may be of interest to compare the Civil Aeronautics Authority system at Indianapolis with the system set up by the National Bureau of Standards at Newark about seven years ago.* Many instrument landings were made on the Newark installation and the setup was considered by many pilots as suitable for airline experimental use. The achievements represented by the Indianapolis setup lie primarily in the provision of control of the individual elements of the system.

It is gratifying to note that every one of the modifications indicated to be desirable by the Newark tests have been incorporated in the Indianapolis system. Bends in the runway-beacon course are eliminated by control of the space-radiation pattern. The required course sharpness is obtained by sharper radiation patterns rather than in the course indicator, thereby providing increased course stability. The marker beacons, taken over from the Army system, have means for controlling the radiated patterns to conform with particular installation requirements. Finally, the glide path is made to have a shape desired by pilots and more easily applied to airports having long runways.

The authors of the paper are to be congratulated on the excellent progress made. The provision of means for controlling the shape of the glide path represents, perhaps, the outstanding achievement. By virtue of these means, the constant-intensity glide path becomes definitely superior to the equisignal type. Aside from the greater flexibility of path shape obtainable, there is considerable simplification and economy of equipment. Careful consideration of all of the factors involved will show that the stability of path is equivalent for the two types.

Since the demonstration at Indianapolis, Y. C. Houghton of the Department of Justice and I have devised, on paper, a second arrangement for controlling path shape which may afford some advantage over that employed at Indianapolis or may be used in conjunction with it to simplify the antenna required. It consists of progressively varying the reflecting coefficient of the ground along a strip in front of the radiating antenna system so that the interference between the direct and ground reflected waves produce paths of constant intensity having shapes which are practically linear. For example, the strip may be 30 feet wide and 150 feet long, extending from a point 100 feet in front of the antenna. The reflection coefficient along this strip is dependent upon the value of the factor

$$K' = K - \frac{2j\sigma c^2}{f},$$

where K is the dielectric constant (electrostatic units), σ is the conductivity (electromagnetic units), f is the frequency (cycles per second), and c is the velocity of light (3×10^{10} centimeters per second). To secure a progressive change in the reflection coefficient along the length of the reflecting strip such as to produce the shape of glide path specified as desirable by the Radio Technical Committee for Aeronautics, the factor K' must be made to vary from a value of about 360 at the point nearest to the antenna to a value of about 2 at the point farthest from the antenna. The desired distribution of the factor K' may be accomplished quite simply by a system of variably-spaced copper strips parallel to each other and perpendicular to the length of the reflecting surface combined with the use of a material of low dielectric constant (such as asphalt) for the surface of the reflecting strip. Note that the maximum conductivity required is of the order of 2×10^{-11} electromagnetic units, approximately that of sea water.

C. Francis Harding (Purdue University, Lafayette, Ind.): No presentation nor discussion of papers upon the application of the cathode-ray oscilloscope to the blind landing of airplanes would be complete without giving recognition to that developed by Professors R. H. George and H. J. Heim of the electrical division of the Purdue Research Foundation.

This system differs from those described in that the oscilloscope in the cockpit of the airplane shows, upon approach to the landing field, six distinct bright spots directed from six small short-wave radio transmitters located at the four corners and the midway side locations of the airport or along the runway. These radio impulses are transmitted on a single wavelength in sequence around the field in such rapid succession that the persistence of vision of the pilot provides the impression of a rectangular outline of lights of proper contour to indicate the shape of the airport and the direction of approach of the plane from any point not necessarily on a radio beacon. Such an indication is, of course, available whether the lights of the airport can be seen or not.

These transmitters, very small in size may be located on the borders of the airport in such a manner as to provide no interference with the landing operation, while the receivers in the plane may be made of sufficiently small size and weight as not to be objectionable. Indeed, the George-Heim system is capable of providing the pilot with more information than the glide-path system, although the Civil Aeronautics Authority-Massachusetts Institute of Technology system approaches most closely to the former. By properly locating the transmitters the system developed at Purdue University can be made to supply the three-light pattern for a glide path as described in the papers under discussion. In addition the outline of the runway or the entire airport would be outlined. It would, therefore, be unnecessary to have other supplementary equipment. If six, or even less, transmitters are used along the runway, the pilot should be able to choose his glide path from the perspective of the light spots.

Such a system has been under development for some time at Purdue University and promising results have been obtained with ground tests. Equipment has been constructed for flight tests which will be undertaken this spring.

* Performance Tests of Radio System of Landing Aids, H. Diamond. Bureau of Standards *Journal of Research*, volume 11, 1933, pages 463–90; *RP*602.